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An evaluation of sustainable construction perceptions and practices in Singapore

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ABSTRACT

Environmental challenges and risks associated with climate change face all of our cities, and the construction industry has a major role to play in terms of changed practice. The Singaporean government has, over a period of many decades, made efforts to address environmental challenges including the implementation in recent years of policies and guidance regarding the design of new buildings. These are regarded as vital to ensuring that the city has a sustainable future.

The research reported in this paper undertook to review perceptions and awareness of sustainable construction methods and policies within the Singaporean construction industry. An in-depth online questionnaire was completed by respondents drawn from the A1 contractors group, with questions concerning both regulation and industrial perceptions, attitudes and action.

With regards to the relative importance of drivers for change, the research indicated that regulatory compliance appeared to be more significant than new practices instigated as a results of changes in attitude and perception alone. A main conclusion of the paper is that government regulatory and incentive programmes may be able to drive positive change effectively and efficiently, but that this needs to happen alongside initiatives to support Client awareness and adoption of sustainable practice.

1. Introduction

The role of the urban scale in responding to sustainability challenges is increasingly recognised. The entirety of Sustainable Development Goa1 11 is given to making cities "inclusive, safe, resilient and sustainable" (UN, 2014). The form of the built environment in particular has significant bearing on society's ability to address climate and sustainability issues through, for instance, energy consumption (Santamouris et al., 2001), ability to address thermal comfort (Chee, Chang, & Wong, 2011) or emissions and waste implications from construction and redevelopment (Hammond & Jones, 2008), aspects that are examined and dealt with through sustainable construction. There is hence an ongoing need to understand innovative solutions at the building scale which can contribute towards an environmentally-friendly and resource-conserving city.

The purpose of this paper is therefore to contribute to this knowledge field through consideration of the Singapore construction industry's perception of, and its effort in practising, sustainable construction. Over the past four decades Singapore, a small island city with an increasing and dense population, has been facing environmental management challenges which have arisen due to rapid industrialisation and economic development. Following Singapore's early successes in understanding the role of greenspace planning in a sustainable city (Tan & Wang, 2013) the Singaporean government has made efforts to implement policies and guidelines towards sustainable building design and construction. Against this background, though, there remains danger that key aspects of sustainability and sustainable construction are misunderstood within the industry itself. Recent research suggests that concerns over durability and availability of green materials are among the key risk factors in green Singaporean commercial building projects (Hwang, Shan, & Binte Supa'at, 2017). As in many other contexts, decisions over the governance of the built environment in Singapore for climate and sustainability purposes are also informed by socio-political factors (Tan, Feng, & Hwang, 2016).

Industry perceptions of sustainability are evaluated via in-depth online questionnaires. A convergent analytical framework is adopted to address the industry's perception of sustainability, drawing on the responses of contractors under the registry category A1 of Building and Construction Authority (BCA). Based on these findings, the paper identifies factors likely to have an impact on the respondents' motivations to practice sustainable construction. It is argued that to fully realise the potential for sustainability in construction, in the Singapore

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context at least there is a need for strong leadership from the government level to mandate sustainable practices, and also for wide-ranging rationales for sustainable construction practices capable of appealing to a range of sectors.

2. Sustainability in the context of construction

The progress of a nation's economy and society has a close relationship with the construction industry. The world's population is urbanising rapidly, predicted to reach 70% by 2050 (UNEP, 2014). City expansion and modernisation is a source of global environmental pollution and ecological damage – yet conversely it is at the city scale where many of the solutions to environmental challenges will be enacted through fine-scale regulations and policy (e.g. Revi et al., 2014; Seto, Parnell, & Elmqvist, 2013). The construction industry is particularly significant within this due to the mineral and biological resources associated with urban expansion and redevelopment (e.g. Hammond & Jones, 2008), which intensify areas of existing environmental stress (Ding, 2008). There has therefore been an increasing requirement for adaption to climate change and resource efficiency in the construction industry (Ofori, 2000), particularly prevention and mitigation of future effects (Ofori, 1998).

While recognition of the need for sustainable construction has emerged globally, the demand is still low or even at its infancy due to lack of awareness (Shafii, Ali, & Othman, 2006; Zhou & Lowe, 2003), misconceptions of what is required and involved and more importantly, the economic barriers that deter stakeholders and contractors in adopting sustainable construction (Hwang & Tan, 2012; Tan, Shen, & Yao, 2011; Zhou & Lowe, 2003). It is hence necessary for further effort to be established on common concepts, principles and techniques relating to sustainable construction; and encouraging enterprises and individual practitioners to make their activities sustainable (Ofori, 1998).

Hoffman and Henn (cited in Medineckiene, Turskis, & Zavadskas, 2010) also note that the construction industry and building design will continue to stall in addressing environmental needs if social and psychological barriers are not addressed. Tan et al. (2011) identify five major areas for practising sustainable construction: (i) compliance with sustainability legislation, (ii) design and procurement, (iii) technology and innovation; (iv) organisational structure and process, and lastly (v) education and training. Crucially, however, despite broad awareness of linkages between sustainability and competitiveness (e.g. Porter & van der Linde, 1995), Tan et al. (2011) in an empirical study in Singapore identify no unique relationship between these factors. One of the key aims of this research is therefore to assess why this may be, and also to understand pathways though which sustainable practice may become more engaging to the construction sector.

A framework becomes a useful guideline for contractors' compliance and practising in order to meet the increasing requirement for sustainable construction (Hill & Bowen, 1997). The adoption of sustainability quality standards such as ISO 9000, ISO 14000 and ISO 14001 EMS (Environmental Management System) in particular, seems to be a better approach to steer the construction industry towards environmental performance (Ball, 2002; Ding, 2008; Kein, Ofori, & Briffett, 1999; Kibert, 2016; Lam, Chan, Chau, Poon, & Chun, 2011; Ofori, Briffett, Gang, & Ranasinghe, 2000; Walker, 2000). Ofori, Gang, and Briffett (2002) note that businesses compelled by the regulatory and competitive pressures, environmental action is now perceived as a strategic advantage as enterprises applying EMS will realise economic benefits.

2.1. Case study: Singapore

A developed and first world country, Singapore has a successful economy and is a financial hub of Southeast Asia. Construction is one of the industries that flourishes with the economy, has also contributed to the environmental pollution and exhaustion of resources, and over a long period of time. Singapore started green efforts as early as in the 1960s with the annual tree planting day, which more recently has developed into city-wide understanding of the role of urban ecosystems in creating a sustainable city (Tan & Abdul Hamid, 2014). Besides raising awareness of environmental sustainability and addressing such issues, Singapore's government aspires to be a leading global city in creating a sustainable built environment. Singapore therefore has implemented various initiatives and regulations such as Sustainable Construction Master Plan 2008, Singapore Green Plan 2012 (also known as SGP 2012), Green Mark Scheme and environmental management system (EMS) to encourage sustainable construction. The focus of these initiatives has been not only on energy efficiency, but also on a holistic approach being taken to encourage environmental friendliness in buildings to ensure that environmental quality and comfort are not compromised. As above, the central aim of this paper is therefore to assess the extent to which these initiatives and regulations have informed construction professionals' understanding of the necessity and benefits of sustainable practice, and to identify opportunities and barriers to facilitating sustainable construction in Singapore and beyond.

3. Methodology

Whilst the importance of national and municipal governments in driving forward sustainable urbanisation is recognised in the literature reviewed in Section 2, it is also true that collaborations across sectors are crucial to realising this sustainability in practice (e.g. Jim, 2004; Miner, Taylor, Jones, & Phelan, 2016) – especially when it comes to buildings where many actions will be undertaken by the private sector. The research thus focused on contractors under the registry category A1 of Building and Construction Authority (BCA). Contractors under this category are companies with unlimited tendering limits and a minimum paid up capital of S$15 million. An extensive and in-depth questionnaire was distributed via professional social media (i.e. LinkedIn), totalling 95 out of the total 104 companies under the BCA A1 contractor listing. In total, the survey received responses from 16 companies, the respondents consisting of senior/executives (42.9%,), managers (50%) and directors (7.1%) respectively. Whilst this may seem a relatively small sample, given the significant technical and regulatory complexity of the topic, a small focused sample of respondents who would be able to provide accurate and in-depth responses was considered more valuable than a more extensive but less informed pool of respondents. Indeed, comparable sample sizes have been used in relevant research focusing on sustainability, like Fritz, Schöggl, and Baumgartner (2017) whose research investigated sustainability performance within supply chains. For tackling the low response rate, Hair, Wolfinbarger, Ortinau, and Bush (2008) recommend that the sampling size can be doubled, however and in the specific case due to the small number of BCA A1 contractors overall, it was essential to contact the 90% of the total companies. Additionally, the response rate is adequate (22%), when considering the research developed by Akintoye (2000) and Dulaimi, Ling, and Bajracharya (2003) who claimed that a typical surveys response within the construction sector have a range of 20%–30%.

The survey aimed to provide a review of the Singapore's construction industry's perception and its effort in practising sustainable construction, reviewing the contractors' perception of sustainability and the potential obstacles encountered by the industry to enacting more sustainable construction practices. The online questionnaire consisted of four sections: (1) general information on the demographic data of the respondents; (2) a list of statements on respondents' awareness on importance of sustainable construction; (3) a list of statements on respondents' attitudes towards the implementation of sustainable construction; (4) potential barriers in practising sustainable construction.

The classification of contractors' positive or negative attitudes on implementation of sustainable construction is based on the following set of criteria:

a) Contractors have obtained ISO 14001 EMS certification; and
b) Contractors have implemented more than 5 environmental practices in their construction activities

The analysis initiated with an examination of all A1 contractors' corporate websites on their mission statements and environmental-related publications. Afterwards, a nonparametric assessment was used to relate sample group's awareness, attitudes towards implementation of sustainable construction to the potential obstacles in such practices. For this purpose, the Spearman rank correlation coefficient and Kendall's Tau-b coefficient tests will assess the monotonic relationships between the ordinal variables. The coefficients provide us with a measure of the strength and degree of the relationship between two sets of variables, and help us to identify where there might be a correlation (cause/effect) between answers. Section 4 presents the analysis steps in greater detail.

4. Results

The analysis is reported in three parts. The first part is a textual analysis of the responding companies' current practices on green construction, using secondary data sources extracted from the firm's archival records of mission statements and published annual reports available from respective respondent's websites as well as respondents' surveyed answers relating to perceptions of sustainability. The second part reviews respondents' perceived obstacles to practising sustainable construction. The third part assesses the correlation between respondents' awareness, attitudes and perception of obstacles.

4.1. Awareness and attitudes towards sustainability

As a pre-requisite for a contractor to carry the A1 registry heading, there are criteria pertaining to green practices which must be fulfilled. Firstly, these firms must have obtained a minimum ISO9001:2008, and secondly, they must be registered under the Green & Gracious Building Scheme (GGBS).

Since 2011, 35.7% of the respondents' average annual turnover was greater than S$501 million, 28.6% with S$201 – S$300 million, 14.3% for both turnover of S$100–S$200 million and 7.1% with S$ 401 – $500 million turnover. 71.4% of projects executed by the respondents consist of both public and private sectors, mainly in residential and commercial, followed by hospitality projects. Only 84.6% of the respondents were awarded with Green Mark Award, however most of these awards were Gold and above. Another more encouraging fact that reflected the respondents' commitment to sustainable construction is that all of them have obtained ISO14001 EMS certification. Notwithstanding that, 64.3% of the respondents have environmental practices in their projects for more than 5 years; 71.4% of these projects implemented more than 5 such practices, including employment of a Green Mark or sustainability officer 78.6% in the respondents' company.

Results revealed that 43.27% of the firms' operations placed emphasis on corporate quality, environmental and resource management, followed by 25% emphasising Environmental Health and Safety (EHS) policy and practices. Emphasis solely on the corporate quality management was almost a close tie with EHS, with these corporations emphasising the specific themes being either public listed companies or having development as one of their core businesses. Firms which publish environmental issues or sustainability reports are majority international corporations; with only a mere 2 out of the 16 corporations are local firms. As such, a firm's approach and commitment towards sustainable construction appears to differ between local and international corporations.

Questions within the survey regarding respondents' understanding of sustainability used a 5-point Likert scale. The results revealed that statement B4 ('Sustainability is about reduce, reuse and recycle only') was ranked highest (Table 1). Similarly, general perceptions of sustainability relating to 'Green' (B2) and higher costs (B3) were ranked second. In contrast, statements that sustainability might refer solely to the environment (B1), lead to a lowering of living standards (B5) and is a population/waste issue (B7) were least supported.

Table 1
Mean and ranking derivation for statements.

Statements on common myths/perception of sustainability.		Mean	*SD	Rank
B1	Sustainability is all about environment only	2.57	1.93	4
B2	Sustainability is a synonym for 'Green'	3.14	1.33	2
B3	Practising sustainability can be expensive	3.14	1.29	2
B4	Sustainability is about Reduce, Reuse and Recycle only	3.29	1.5	1
B5	Sustainability means lowering our standard of living	1.64	1.72	5
B6	New technology is the only solution to sustainability	2.79	2.48	3
B7	Sustainability is a pollution problem (e.g. more people, more wastes are generated)	0.5	2.3	6

* SD – Standard Deviation.

At the same time, when respondents were asked about their awareness and attitudes towards sustainable construction, there was consensus that greater success of such practices would only be possible and achievable when there was participation and commitments from stakeholders and consultants. This is evidenced by the highest mean scores for statements C10 ('success of sustainable construction will not be possible without the commitments from stakeholders and consultants') and D9 ('sustainable construction should not be limited to contractors alone. Greater success will be achieved with participations and commitments from stakeholders and consultants.') of Tables 2 and 3 have the highest mean scoring; especially if the adoption of such practices are to begin at design stage for maximum performance.

Respondents revealed the provision of education on green practices throughout all level of staff from office to site operating teams. Aiming to increase efficiency and reduction of resources, adherence to ISO 14001 EMS standards, implementing recycling programmes and procuring environmental friendly products are some basic steps to begin with, as were similarly reported by Fritz et al. (2017), Ding (2008), Kein et al. (1999) and Kibert (2016). Further steps such as using equipment which generates less noise and smoke emission, using less polluting biofuel for machinery and proper house-keeping are also implemented to reduce damage to our environment. In spite of 71.4% of the respondents indicating that capital costs do increase with green practices, however, such costs were felt to be justified by the economic benefits throughout the construction process, including the extended life cycle of buildings. Only 28.6% of the respondents felt that such practices do not incur capital costs in their organisations.

In summary, the increasing awareness and positive attitudes towards sustainability and green construction are encouraging signs for the industry, including additional voluntary initiatives implemented by the firms. The requisites for authority compliances and government's incentive programmes are also plus points when firms do have these practices in place, creating a win–win situation for all (Oo & Lim, 2011). To further develop this potential, the findings indicate that cross-sector collaboration on sustainable construction and a supportive policy and regulatory framework may be beneficial. We now assess the barriers to attaining this.

4.2. Obstacles to practicing sustainable construction

Having explored respondents' perception and positive attitudes towards sustainable construction, the research went further to find out if there were other factors that hinder the implementation of these practices. In this section of the survey, respondents were asked to rank 12 potential obstacles in practising sustainable construction. As shown in Table 4, all 'obstacles' were ranked higher than the mid-point, although perceptions of high cost, complex building codes and

Table 2
Awareness of sustainability and impact on environment.

	General Statements on Awareness of Sustainable Construction and Impact on Environment	Mean	*SD	Rank
C1	Sustainable construction can reduce resources.	3.69	1.28	7
C2	Sustainable construction can improve energy efficiency.	3.92	1.04	5
C3	Setting minimum standards through legislative requirements.	3.85	1.14	6
C4	Recycled or environmental friendly materials are 'Green' labelled.	3.85	0.89	6
C5	There are various types of construction waste materials available for recycling.	4.08	0.76	3
C6	Implementation of ISO 14001 EMS for sustainable construction is to achieve better environmental performance.	3.92	0.86	5
C7	Utilisation of high performance insulation protection, water and energy saving equipment etc. are less damaging to the environment, but often increase the capital cost.	4	0.91	4
C8	There will be time impact in practising sustainable/green construction.	3.15	1.09	8
C9	Sustainable construction should begin from design stage rather than construction stage.	4.38	1.12	2
C10	Success of sustainable construction will not be possible without the commitments from stakeholders and consultants.	4.69	1.11	1
C11	There are limited selections of environmental friendly materials.	2.85	1.28	9

* SD – Standard Deviation.

regulations and a lack of expressed interest from stakeholders were ranked highest. This parallels respondents' perception of achievement of greater success when stakeholders fully embrace the advantages and benefits of adding green value and extending the building's life cycle.

This finding reflects previous research in this area. Williams and Dair (2007) report the most commonly cited barriers to achieving sustainability as (i) sustainability measures not being considered by stakeholders; (ii) sustainability measures costing too much, and (iii) a lack of adequate, reliable and available sustainable products or equipment. One of the reasons that stakeholders lack of interest could be due to their perception of sustainable construction project risks (Rafindadi, Mikić, Kovačić, & Cekić, 2014, with perceived risks specific to commercial projects explored in Hwang et al., 2017). Shen, Tam, Tam, and Ji (2010) indicate the relevance of incorporating sustainable development principles when conducting project feasibility studies, but warn that the importance of incorporating such principles and insufficient examination of project performance during the project feasibility study was not effectively understood by stakeholders.

The survey responses add additional granularity to this knowledge. Respondents indicate some of the contributing reasons were due to limited certification bodies and materials available in Singapore market (E4) which limits the adoption of such green materials and technologies to be used. Therefore, contractors are sceptical about the performances of these green materials and equipment that can benefit the project. Moreover, when their competitors are using less environmental friendly materials because they are less costly, contractors are compelled to follow the same footsteps in order to survive in the competition.

When respondents were asked what factor(s) contributed to implementing their current practices, 93% of respondents admitted these implementations were for regulatory compliance and contractual obligations; and the remainder was solely voluntary basis. More than 66% of respondents also named parameters such as government incentive programmes, attractive tax rebates, economics; social and environmental benefits when considering implementation of environmental practices. Regardless of regulatory compliance or contractual obligations, respondents do agree that with these practices in place, there is increased efficiency while resources are reduced. Reflecting the findings from Section 4.1., then, to realise the gains in sustainable construction that may come from enhanced cross-sector collaboration there may be need to develop messaging and framing around the economic and efficiency gains that may come from sustainable construction practices.

4.3. Correlation tests between awareness, attitudes and obstacles

To further understand the extent to which the perception and opportunities and obstacles to sustainable construction practice identified in Sections 4.1. and 4.2. relate to awareness and attitudes, correlation tests were undertaken. The Spearman rank correlations and Kendall's coefficient tests were conducted among contractor's awareness, attitudes and perceived obstacles in practising sustainable construction. The tests were conducted on four topics of sustainable construction, namely: (i) perspective of implementing green construction as early as design stage, (ii) the selection of specifications,(iii) implementing reduced and recycled of construction waste;(iv) obstacles in practising green construction.

Table 3
Contractors' attitudes towards sustainable construction practices.

	General Statements on Attitudes of Implementation of Sustainable Construction	Mean	*SD	Rank
D1	Raising awareness through education, sharing platform via conferences and exhibitions.	4.15	1.07	3
D2	Specifications and construction methods should consider environmental requirements.	4.13	1.11	4
D3	To reduce material and construction waste.	4	1.08	6
D4	Improvements on quality, health and safety issues when sustainable construction is implemented.	4	1	6
D5	Public sector should take the lead in implementation of green construction.	4.23	1.16	2
D6	Implementation of green construction is enforced by government.	3.31	0.96	10
D7	Adopting green construction should be voluntary.	3.38	1.13	9
D8	Collaborative research & development (R&D) with industry for new and/or improved technologies (e.g. further development on re-application of recycled materials).	4	0.76	6
D9	Sustainable construction should not be limited to contractors alone. Greater success will be achieved with participations and commitments from stakeholders and consultants.	4.31	1.49	1
D10	Attainment of BREEAM, LEED, or Green Mark certification reflect the sustainability achievements throughout the construction process and eventual building life cycle.	3.54	1.05	8
D11	To comply with the statutory and/or client's requirements.	3.23	1.23	11
D12	It can enhance the company's competitiveness in bidding jobs.	3.77	0.72	7
D13	It can enhance the company's public image.	4.08	1.04	5
D14	Lost in competitiveness (i.e. competitors often uses materials which are less environmental friendly and at a lower cost).	3.15	1.34	12

* SD – Standard Deviation.

Table 4
Potential obstacles in sustainable construction practices.

	Potential Obstacles in Practising Sustainable Construction	Mean	*SD	Rank
E1	High cost incurred in green practices and technologies (e.g. utilisation of high performance insulation protection, water and energy saving equipment often increase the capital cost).	3.62	1.19	2
E2	Insufficient incentives from government for sustainable construction.	3.23	1.16	7
E3	Incremental time caused by green construction.	3.31	1.03	6
E4	Imperfect or immature green technology specifications	3.54	0.78	3
E5	Uncertainty in the performance of green materials and equipment.	3.46	0.88	4
E6	Lack of knowledge on sustainable construction.	3.31	1.03	6
E7	Conflicts in benefits with competitors (i.e. competitors often uses materials which are less environmental friendly and at a lower cost).	3.46	1.2	4
E8	Complex building codes and regulations cause difficulties in evaluating cost involved for such compliance. Stakeholders often fail to see convincing benefits behind practice of sustainable construction	3.85	1.14	1
E9	Lack of management support and time to implement green practices	3.54	0.97	3
E10	Lack of communication and interest amongst project team members	3.38	1.04	5
E11	Lack of expressed interest from stakeholders and market demand	3.85	0.69	1
E12	Resistance to change from conventional to green practices by company's employees	3.38	0.65	5

* SD – Standard Deviation.

Table 5
Spearman rank correlations and Kendall's coefficients between awareness (B9), attitudes (C9) and obstacles (D11) towards sustainable construction – Perspective of implementing green construction.

			Green construction should start from design stage	Green construction not limited to contractors alone	Lack of interest from stakeholders and demand
Kendall's tau_b	Green construction should start from design stage	Correlation coefficient	1.000	1.000	1.000
		Sig. (2-tailed)		0.119	0.233
		N	13	13	13
	Green construction not limited to contractors alone	Correlation coefficient	0.426	1.000	0.225
		Sig. (2-tailed)	0.119		0.404
		N	13	13	13
	Lack of interest from stakeholders and demand	Correlation coefficient	0.320	0.225	1.000
		Sig. (2-tailed)	0.233	0.404	
		N	13	13	13
Spearman's rho	Green construction should start from design stage	Correlation coefficient	1.000	0.456	0.334
		Sig. (2-tailed)		0.117	0.265
		N	13	13	13
	Green construction not limited to contractors alone	Correlation coefficient	0.456	1.000	0.270
		Sig. (2-tailed)	0.117		0.372
		N	13	13	13
	Lack of interest from stakeholders and demand	Correlation coefficient	0.334	0.270	1.000
		Sig. (2-tailed)	0.265	0.372	
		N	13	13	13

On the first topic, perspective of implementing green construction, the mean scores for statements of awareness (B9), attitudes (C9) and obstacles (D11) were 4.38, 4.31 and 3.85 respectively; however, the results in Table 5 showed positive coefficient of medium strength, but there is no significant statistic correlation (Sig. 2-tailed) between these statements. In other words, the extent of awareness, attitudes and perceived obstacles did not have a significant effect on perspective of implementing green construction.

On the second topic with regard to material specifications, results not only showed large strength of positive coefficient, but also significant statistic correlations (Sig. 2-tailed) ($r = 0.781$ and 0.805, $p < 0.01$) (see Table 6, where the significant correlations are denoted **). Similar results showing high strength of positive coefficient and significant statistic correlations (Sig. 2-tailed) ($r = 0.578$ and 0.649, $P < 0.05$) for topics on construction waste and obstacles in green constructions ($r = 0.702$ and 0.738, $P < 0.01$) as shown in Tables 7 and 8 and respectively (significant correlations are denoted * and **).

The above results generated from the four topics of perspective of implementing green construction, material specifications, construction waste and obstacles demonstrated positive coefficients of medium to large strength parameters. The Sig. 2-tailed statistical correlations were applicable to all, except for perspective of green construction implementation. In other words, the primary barriers in practising sustainable construction as perceived by the industry within our Singapore study are only economic and policy factors. The results indicate that there does appear to be a significant relationship between management support/efforts to reduce construction waste and, the relationship between stakeholders understanding the benefits of sustainable construction against awareness of green construction more generally. This suggests that awareness of the subject may not, in itself, prompt behavioural change, in the absence of there being evidence and knowledge of the costs and benefits which might accrue through adoption.

5. Discussion and conclusions

As noted, Singapore has a long track record of addressing sustainable practice, with more recent regulation having a significant effect on specification and practice. The construction industry in Singapore has thrived as a result of the city state being a key financial hub in the Southeast Asia region. As a consequence, the industry has contributed

Table 6
Spearman rank correlations and Kendall's coefficients between awareness (B4), attitudes (C2) and obstacles (D2) towards sustainable construction – Material specifications.

			Environmental friendly are green labelled materials	To consider environmental friendly specifications	Imperfect/immature green technology
Kendall's tau_b	Environmental friendly are green labelled materials	Correlation coefficient	1.000	0.781**	0.396
		Sig. (2-tailed)		0.003	0.126
		N	13	13	13
	To consider environmental friendly specifications	Correlation coefficient	0.781**	1.000	0.501
		Sig. (2-tailed)	0.003		0.059
		N	13	13	13
	Imperfect/immature green technology	Correlation coefficient	0.396	0.501	1.000
		Sig. (2-tailed)	0.126	0.059	
		N	13	13	13
Spearman's rho	Environmental friendly are green labelled materials	Correlation coefficient	1.000	0.805**	0.421
		Sig. (2-tailed)		0.001	0.152
		N	13	13	13
	To consider environmental friendly specifications	Correlation coefficient	0.805**	1.000	0.523
		Sig. (2-tailed)	0.001		0.067
		N	13	13	13
	Imperfect/immature green technology	Correlation coefficient	0.421	0.523	1.000
		Sig. (2-tailed)	0.152	0.067	
		N	13	13	13

** Correlation is significant at the 0.01 level (2-tailed).

significantly to environmental pollution and exhaustion of resources. The research indicates that whilst respondents positively embraced the ideas and aspirations of sustainability, and that there was some evidence of enhanced practice, that major changes in the industry had been driven through regulation and material specification requirements. This perhaps suggests the Government may be able to drive change through the likes of new regulation and incentive programmes.

It is important to acknowledge the limited sample size of this research, and the focus on A1 Contractors in the respondent population. Nonetheless, the survey itself was sufficiently in-depth to ensure that results provided were informative and carried explanatory purchase, and the survey findings are supported by the review of companies' sustainability statements. The apparent importance of the Client within the decision-making chain, and the inclusion of smaller or sub-contractors within further study would be useful. Although it could be anticipated that commercial sensitivities might limit the use of

Table 7
Spearman rank correlations and Kendall's coefficients between awareness (B5), attitudes (C3) and obstacles (D9) towards sustainable construction – Construction waste.

			There are various types of construction waste for recycling	To reduce construction waste	Lack of management support and time for implementation
Kendall's tau_b	There are various types of construction waste for recycling	Correlation coefficient	1.000	0.135	0.372
		Sig. (2-tailed)		0.614	0.151
		N	13	13	13
	To reduce construction waste	Correlation coefficient	0.135	1.000	0.578
		Sig. (2-tailed)	0.614		0.022
		N	13	13	13
	Lack of management support and time for implementation	Correlation coefficient	0.372	0.578*	1.000
		Sig. (2-tailed)	0.151	0.022	
		N	13	13	13
Spearman's rho	There are various types of construction waste for recycling	Correlation coefficient	1.000	0.157	0.407
		Sig. (2-tailed)		0.608	0.167
		N	13	13	13
	To reduce construction waste	Correlation coefficient	0.157	1.000	0.649*
		Sig. (2-tailed)	0.608		0.016
		N	13	13	13
	Lack of management support and time for implementation	Correlation coefficient	0.407	0.649*	1.000
		Sig. (2-tailed)	0.167	0.016	
		N	13	13	13

* Correlation is significant at the 0.05 level (2-tailed).

Table 8
Spearman rank correlations and Kendall's coefficients between awareness (B10), attitudes (C1) and obstacles (D8) towards sustainable construction – Obstacles in practising green construction.

			Success comes from stakeholder commitment	Raising awareness of green construction	Stakeholders fail to see benefits
Kendall's tau_b	Success comes from stakeholder commitment	Correlation coefficient	1.000	0.505	0.421
		Sig. (2-tailed)		0.071	0.125
		N	13	13	13
	Raising awareness of green construction	Correlation coefficient	0.505	1.000	0.702**
		Sig. (2-tailed)	0.071		0.008
		N	13	13	13
	Stakeholders fail to see benefits	Correlation coefficient	0.421	0.702**	1.000
		Sig. (2-tailed)	0.125	0.008	
		N	13	13	13
Spearman's rho	Success comes from stakeholder commitment	Correlation coefficient	1.000	0.520	0.443
		Sig. (2-tailed)		0.068	0.129
		N	13	13	13
	Raising awareness of green construction	Correlation coefficient	0.520	1.000	0.738**
		Sig. (2-tailed)	0.068		0.004
		N	13	13	13
	Stakeholders fail to see benefits	Correlation coefficient	0.443	0.738**	1.000
		Sig. (2-tailed)	0.129	0.004	
		N	13	13	13

** Correlation is significant at the 0.01 level (2-tailed).

qualitative approaches (including the likely value of focus discussions with Client groups), this should be explored in future work as a means of building a fuller picture of opportunities and challenges for working towards sustainable practice in construction.

From a practical perspective, and especially with the noted rise in awareness of sustainability among contractors (see particularly Table 1), it would be useful to explore the extent to which this awareness has translated into practical adoption. This is especially so where the majority of respondents adopted proactive environmental strategies such as waste reduction and prevention of pollutants at source.

From a scholarly perspective, the findings reported in this paper are broadly consistent with extant research into sustainable construction practices. However, the Singapore results reinforce and nuance this literature in three ways. First, the role of perception and potential misconceptions within the industry as a barrier to sustainable construction reflects the observations of Hueting (1996), Leal Filho (2000) and Rogers (2016) on limited understanding of population, environmental conservation, cost, policy and technological factors as barriers to sustainability. As such, developing pathways to building contractor understanding of the importance and value of sustainability may be a useful first step in eliminating negative perceptions. Second and related, the perception of economic concerns as a barrier to undertaking sustainable construction practices emphasises the need for further messaging on the social, economic and environmental value of sustainable practice, creating multiple rationales for sustainable practice that a range of stakeholders can buy into. Chu, Anguelovski, and Roberts (2017) and Shih and Mabon (2017) similarly advocate such strategic messaging and actions as a means of realising practical gains on urban environmental issues in situations of high environmental and socio-political complexity. Third, the findings of this study – particularly the importance of regulatory compliance as a driver for sustainable construction practice and the expectation that the public sector leads – reinforce the importance of strong policy and regulation from the municipal and national level in realising sustainable built environments. Nevertheless, observations from urban ecological planning in Singapore (Tan et al., 2016) and urban sustainability in analogous dense cities like Taipei (Chang, Seto, & Huang, 2013) indicate the policymaking process for the built environment can be swayed by socio-political interests. There may hence be a need for continued critical reflection on the extent to which public sector and government processes such as building codes are able to mandate sustainable practice in the face of economic development pressures.

Lastly, it is worth noting the policy significance of the research. In the region of Southeast Asia, a long-term sustainable development framework was affirmed in 1997 ASEAN Summit (Shafii et al., 2006). Construction has been included as one of the goals in ASEAN Vision 2020 to envisage "*a clean and green ASEAN with fully established mechanisms for sustainable development to ensure the protection of the region's environment, the sustainability of its natural resources, and the high quality of life of its peoples*." Given Singapore's position as one of the leaders in sustainable construction in the region plus the rapidly urbanising nature of the southeast Asian area as a whole, our findings suggest realising this aspect of ASEAN Vision 2020 may necessitate (a) raising awareness and building positive messaging around sustainable construction within contractors; and (b) working across national and municipal government levels to build sustainable practices into areas such as building codes and land use regulations.

The research reported in this paper suggests that whilst certain preconceptions about the realities of sustainable construction might well persist, the enshrining of practical routes to the adoption of sustainable practice within material specification and regulation are likely to have the greatest and most significant effect on work practices. The study results showed a widespread awareness within the industry of the importance of sustainable construction and its impact on the environment, although the influence of Client awareness and perceived value of sustainable design and practice appeared to still represent a barrier to adoption.

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